

REVISION OF THE NORTH AMERICAN SLUGS: *ARIOLIMAX* AND  
*APHALLARION*.

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The genera of slugs inhabiting North America have hitherto been discriminated by *external* characters, and those of the jaw and teeth. We purpose to indicate, in a series of papers of which this is the first, some of the more important of their *internal* features, particularly the genitalia and alimentary canal.

The genitalia have been utilized by Mr. W. G. Binney and others for the discrimination of species; and we have already considerable knowledge of these organs from his descriptions and drawings; but, of late, quite a new stress has been laid upon certain characters of the organs of generation. By Dr. Simroth, in Germany, and the senior author of this paper in America, characters of generic, as well as of still higher value, have been found in the genitalia. It is, therefore, important to review our data upon the anatomy of American slugs, to correct the numerous misinterpretations of organs which have arisen from lack of good material or other causes, and to expose the true generic characters and affinities of these animals, so far as may be possible in the present state of our knowledge.

As the *species* of slugs also rest largely upon characters of internal anatomy, their revision will be attempted; a work now most timely, in view of the fact that such a multitude of insufficiently defined specific and varietal names have been proposed that he who attempts the identification of a West Coast slug to-day is not only a bold man but also one probably doomed to a miserable failure.

The largest slugs of America, *Ariolimax* and *Aphallarion*, are selected for the present essay.

No correct figures or descriptions of the genitalia of these animals have yet been published. The true structure of the male organs of *Ariolimax* is here for the first time made known; and the genus *Aphallarion* is proposed for a new species, perhaps the largest American slug, remarkable in lacking a penis.<sup>1</sup>

<sup>1</sup>We must acknowledge our indebtedness to P. B. Randolph, of Seattle, Washington, and to Fred L. Button, of Oakland, California, for large series of slugs used in preparing this paper.

## EXTERNAL CHARACTERS.

The external characters of *Ariolimax* and *Aphallarion* are described below. *Arion* differs from these American groups in the rounded, not keeled, back, the anterior breathing pore and the more posterior genital orifice.

## JAWS AND TEETH.

The jaw in *Ariolimax* and *Aphallarion* is of the ribbed type usual in *Arionidæ*, and does not differ materially from that of *Arion*. The teeth offer no characters of generic importance, being of the general type found throughout *Arionidæ*. Those of the median part of the radula are of the Helicid form; the marginal teeth develop long mesocones, simulating somewhat the teeth of *Zonitidæ*, precisely as those of some *Endodontidæ* do.

## DIGESTIVE SYSTEM.

In *Arion*, *Ariolimax* and *Aphallarion* the alimentary canal is distinctly differentiated into fore-, mid- and hind-gut. The short œsophagus leads into a capacious crop, *which is separated by a decided constriction* from the stomach, which lies near the posterior end of body. At the termination of the stomach the bile duct enters, near the origin of the intestine. The latter presents, after coiling spirally once around the visceral mass, an *anterior loop*, lying to the right of the albumen gland. Passing backward it coils in a reverse direction around the visceral mass and forms a *posterior loop*, which, in the American forms (Pl. XIII, figs. 2, 4) lies behind, in the European (*Arion*, Pl. XIII, fig. 3) above and anterior to the main mass of the stomach. From this loop the intestine passes forward, describing a spiral coil again reversed in direction, and terminates near the respiratory orifice on the right side of the body anteriorly.

The digestive systems of the three genera *Arion*, *Ariolimax* and *Aphallarion* differ only in subordinate features. In *Arion*, the stomach, as mentioned above, lies behind the posterior loop of the hind-gut. In *Ariolimax* and *Aphallarion* the posterior loop lies behind the stomach. *Aphallarion* differs from the other two genera in having a spiral turn less of the intestine. As usual in slugs there are four lengthwise folds of the gut.

A very long and (for a slug) complexly disposed intestine, and a complete separation of crop and stomach, are the peculiar characteristics of these great slugs. This will become more apparent when

we compare it with the simpler and very different digestive tract in *Prophysaon*, *Limax*, or the *Helices*.

The liver extends forward nearly as far as the anterior loop of the intestine, and backward to the tail (Pl. XIII, fig. 1), enveloping and partly concealing the convolutions of the intestine in all three genera.

The suboral gland (Pl. XIII, fig. 1) is about half as long as body, and lies free, not imbedded in the muscles of the foot.

#### GENITALIA.

In *Arion*, *Ariolimax* and *Aphallarion* the genitalia lie quite differently in the body-cavity from those organs in *Limax* or *Prophysaon*, the whole system being crowded forward. The albumen gland (Pl. XIII, figs. 1 and 2) lies to the left of the anterior loop of the intestine, almost entirely forward of the middle of the body-cavity. The distal end of the albumen gland turns down the left side and extends part way across the body beneath, often showing a longitudinal impression made by the suboral gland. (This is seen at *l. gr.* in fig. 14 of Plate XIV.) At the base of the albumen gland the ovotestis is closely packed (Pl. XIII, fig. 1) in *Ariolimax* and *Aphallarion*, and its duct is largely imbedded in the albumen gland; but in *Arion* the ovi-sperm duct follows the course of the mid-gut backward, and the ovotestis is situated at the tail, behind the stomach (Pl. XIII, fig. 3).

The penis in *Ariolimax* lies obliquely across the viscera, overlying salivary glands and crop. It is seen removed from its natural position in Pl. XIII, fig. 1.

In treating of *Arion* and allied forms, Dr. Simroth, the distinguished German malacologist, has discriminated between a true penis and that enlargement of the anterior end of the vas deferens seen in *Arion*, etc., which he has termed the *Patronenstrecke*.

The senior writer, in dealing with *Helices*, made the same distinction.<sup>2</sup> The penis is an evertable sack, provided with a retractor muscle. The "*Patronenstrecke*," or, as we have termed it, the *epiphallus*, is not evertable, and has no retractor muscle; its function being merely to gather the spermatozoa into packets or spermato-phores; and it is strictly homologous with the lower portion of the vas deferens of ordinary snails. In the vast majority of snails in which the vas deferens is modified into an epiphallus, it occurs in connection with a normally developed penis, as in fig. 14, Pl. XIV. In *Arion*, *Aphallarion*, *Prophysaon*, and some other genera, the true

<sup>2</sup> Proc. Acad. Nat. Sci. Phila., 1892, p. 388.

penis has been lost, and the epiphallus directly enters the atrium. In these forms the vagina assumes the function of an evertable penis, an extraordinary but by no means unparalleled instance of change of function.

These matters are here dwelt upon somewhat fully, because in all former American work on slug anatomy, no discrimination whatever has been made between the penis and the epiphallus, the very real and important morphologic facts involved being, therefore, entirely ignored.

The most prominent general feature of the genitalia in the three genera is the crowding of the main mass forward into the anterior half of the body-cavity.

#### GENERIC CHARACTERS.

The three genera of *Arionidae* mentioned above are seen by the foregoing general description to present many common features in their digestive and generative organs, showing them to be nearly allied. Their main differential characters are shown in the following analysis:

- I. Respiratory pore anterior, the genital orifice below it. No caudal mucus pore. Back rounded in adults. Stomach extending back of posterior loop of intestine. No penis, an epiphallus replacing it; ovotestis widely separated from the albumen gland, situated in the cavity of tail, behind the stomach (see Pl. XIII, fig. 3, *A. hortensis*), Genus *ARION* Férussac.
- II. Respiratory pore behind middle of shield. Genital orifice near right tentacle. A caudal mucus pore. Back keeled, at least toward the tail. Posterior loop of intestine behind stomach. Ovotestis packed close to the base of albumen gland.
  - a. No penis, a short epiphallus replacing it (see Pl., XIV. fig. 12); right eye retractor passing to the left of genitalia. Genus *APHALLARION* Pilsbry and Vanatta.
  - aa. A well developed penis, with short, fleshy retractor muscle; epiphallus more or less introverted in penis (see Pl. XIV, figs. 7, 8, 9, 14); right eye retractor passing between ♂ and ♀ branches of genitalia, Genus *ARLIOLIMAX* Mörch.

One species of the Palearctic genus *Arion* has been introduced by commerce within our limits, *A. hortensis* Fér. It occurs at Boston and New Bedford, Mass.; Poughkeepsie, N. Y.; Seattle, Wash., etc.

Genus *ARLIOLIMAX* Mörch.

EXTERNAL CHARACTERS.—Body limaciform, its posterior half more or less keeled on the back; foot margin defined by deep pedal

grooves, deeper toward the more or less distinct caudal mucus gland. Mantle oval, about one-fourth as long as the entire body, finely granular, the respiratory orifice at its posterior third near the right edge. Genital orifice behind the right eye tentacle. Orifice of the suboral gland very broad. Integument scored by numerous grooves, longitudinal behind, obliquely descending below the mantle and for some distance along the flanks.<sup>3</sup> Sole tripartite, the divisions rather indistinct; alcoholic specimens having the median band smooth, lateral bands finely transversely wrinkled.

The principal internal characters of the genus are mentioned above. The extraordinary modification of the penis is fully described below.

*Key to species of Ariolimax.*

- a. Mantle free anteriorly for about one-third of its length. Penis with terminal retractor, and nearly filled for its entire length by the invaginated epiphallus; vas deferens not enlarged, *Columbianus*.
- aa. Mantle free anteriorly about one-fourth of its length. Penis hollow, with very broad retractor, beyond which it is attenuated; vas deferens enlarged into an epiphallus external to the penis, the invaginated portion small. *Californicus*.

**A. Columbianus** Gould. Plate XII, fig. 2.

*Limax Columbianus* Gld. in *Terrestrial Moll. U. S.*, II, p. 43, pl. 66, f. 1 (1851); *U. S. Expl. Exped.*, *Moll.*, p. 3, pl. 1, f. 1 (1852); Tryon, *Amer. Jour. Conch.*, III, p. 315 (1868).

*Ariolimax Columbianus* Mörch, *Malak. Blätter*, VI, p. 110 (1859). W. G. Binney, *Amer. Journ. Conch.*, I, p. 48, pl. 6, f. 11-13; *Land and Fresh Water Sh. N. A.*, I, p. 279, f. 496-501, (1869); *Proc. Acad. Nat. Sci.*, Phila., 1874, p. 33, pl. 2, f. B. to H; *Terr. Moll.*, V, p. 231, pl. v, f. E (dentition), pl. xii, f. C (genitalia); *Man. Amer. L. Shells*, p. 98, f. 58, 59, 60, 61; *Third Supplement to Terr. Moll.*, V (*Bull. Mus. Comp. Zool.*, XIX, No. 4), p. 211, pl. vi, f. A (mottled form) and f. G (penis).

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<sup>3</sup> Mr. Charles Hedley, the accomplished Australian student of mollusk morphology, considers the oblique surface grooves as characteristic of the *Aulacopoda* generally. I quote this passage from a recent letter: "Besides the pedal grooves, tail pore and horn, the typically developed *Aulacopod* has a keeled tail and oblique secondary grooves. The pore may be lost by degeneration, so, too, may the oblique grooves; and the keeled tail may become flattened. Nevertheless, both are typical characteristics, and deserve mention in the diagnosis. Again, the *Holopoda* have long tapering eye tentacles, with bulbous tips, but the *Aulacopoda* have shorter cylindrical tentacles, less bulbous at tip and set wider apart."

There can be no doubt that the features mentioned by my friend are of very frequent occurrence in the *Aulacopoda*, while they do not occur in *Holopoda*; but they are not invariable, the pedal grooves being, I believe, the only strictly diagnostic external character of the group.—H. A. P.

- Ariolimax Columbianus forma typicus* Cockerell, Nautilus, V, p. 31 (1891).  
*Ariolimax Columbianus forma maculatus* Ckll., Nautilus, V, p. 31. Binney, Third Suppl. to Terr. Moll., V (Bull. Mus. Comp. Zool., XIX, No. 4), p. 211, pl. vi, f. A.  
*Ariolimax Columbianus forma niger* Ckll., Nautilus, V, p. 32.  
*Ariolimax subsp. Californicus forma maculatus* Ckll., Nautilus, V, p. 31 (foot note).  
*Ariolimax Columbianus* var. *stramineus* Hemphill, Nautilus, IV, p. 130 (Feb., 1891).

GEOGRAPHIC DISTRIBUTION.—British Columbia (J. H. Keen); Victoria (H. F. Wickham); Washington, at Tacoma, and North Bend, about 25 miles east of Seattle in the foot-hills of the Cascade Mts. (P. B. Randolph); Nesqually (Case); Discovery Bay, Puget Sound (Dyes); San Juan Island (Hemphill); California, at St. Helena, Napa Co. (Hemphill); Santa Cruz Island (Hemphill, var. *stramineus*).

Color of alcoholic examples a lighter or darker shade of reddish-brown, or sometimes ochraceous. Foot margin without dark vertical lines (see descriptions of varieties).

Melanistic form: Color of alcoholic specimens a slightly reddish-brown, marked with large, irregular scattered black spots along the sides, and with a rounded black spot on the mantle behind the middle. In some specimens the spots on each side coalesce into a large, irregular black area.

Anterior third of mantle free.

Jaw (Pl. XIV, fig. 10) with 13 to 17 ribs and riblets, which sometimes do not denticulate the basal margin; but there is variation in this respect. Teeth about as in *A. Californicus* (q. v.), but the outer laterals have less lengthened cusps, and there are rather fewer bicuspid outer marginals. The differences between the teeth of the species are too slight to be of any practical diagnostic value.

Shell oblong, convex above, calcified in the middle, but with a broad, yellow, uncalcified peripheral portion. Nucleus median, near the posterior end. Length 12, breadth  $6\frac{1}{2}$ , convexity  $1\frac{1}{2}$  mm.

The general internal structure (pl. XIII, fig. 1) and the digestive tract (pl. XIII, fig. 2)<sup>4</sup> have been sufficiently described above.

The genitalia (Pl. XIV, fig. 7, typical form, and figs. 8, 9, black-spotted form) present a rather long and stout penis, receiving the vas deferens and a very short retractor muscle at its apex; upon opening the penis longitudinally (fig. 9) it is seen to contain a large

<sup>4</sup> Compare Binney's figure of the digestive system in Proc. Acad. Nat. Sci., Phila., 1874, pl. II, f. D, F.

inner body, which extends to the external orifice, where it terminates in a penis-papilla (fig. 9, *P. papilla*). This internal body consists

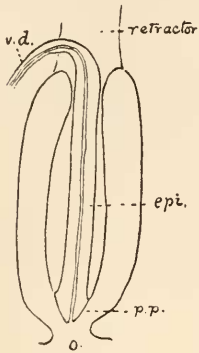


Diagram of the penis of *Ariolimax*. *v. d.* vas deferens; *epi.* invaginated epiphallus; *p. p.* perforated penis papilla, elevated on the epiphallus; *o.* external opening of penis.

muscle, inserted high. Spermatheca situated high, on a short duct. Other organs call for no special remark.

*A. Columbianus* is a dimorphic species in most, perhaps all, localities. There is a unicolored form, and one more or less heavily spotted or blotched with black. This maculated form has received the name "*forma maculatus*" Ckll. It is in no sense a true variety or subspecies but merely a "form," comparable to the *glaucus* form of the dimorphic *Papilio turnus*.

Cockerell's "*forma niger*" was described from one specimen in which the black blotches had coalesced, upper surface entirely black,

of a fleshy cylindrical tube (fig. 9, *epi.*) enveloped by a very thin-walled and minutely corrugated outer tube (fig. 9, *sheath of epi.*). This structure we can only interpret as an introverted epiphallus, which has extended entirely to the proximal opening of the penis, carrying the penis-papilla at its summit. This will be more clearly seen in the annexed diagram. The clearer, because less advanced, penial morphology of *A. Californicus* bears out this view of the structure in *A. Columbianus*, which is, moreover, more readily seen in our preparations than in the flat figures, necessarily complicated by lines to show the ducts and layers of tissue not visible from the outside<sup>5</sup>

The female side shows a rather long vagina, provided with a broad, split retractor

<sup>5</sup> A similar penial structure has very recently been described and figured by Charles Hedley in the epiphallagonous genus *Xanthomelon* of the *Helicidae*. In *X. fodinalis* Tate and *X. Adcockiana* Bednall, a tube occupies the penis cavity. "This," writes Hedley, "I interpret with some hesitation as an invaginated epiphallus, of which the distal end has grown to the atrium wall, and which has drawn after it into the penis sac both vas deferens and the retractor" (see Hedley's anatomical appendix to Professor Ralph Tate's report on the Mollusca of the Horn Expedition to Central Australia).

No such structure has been described before; and we are disposed to accept Hedley's ingenious interpretation of the morphologic problem. In *Xanthomelon* the invaginated epiphallus is attached at the proximal end of penis sac. This is not the case with *Ariolimax*, in which the invaginated structure is to that extent clearer.

from the humid British Columbian region, in which melanism is of common occurrence in snails, birds and mammals. In a series of several hundred examples we find great variation in the extent of the black marking.

We hazard little in assuming that "*A. Californicus forma maculatus*" Ckll. is identical with the spotted form of *Columbianus*, and has nothing whatever to do with the true *A. Californicus* Cooper. Like a good many "varieties" of slugs, this is "such stuff as dreams are made of."

We have opened numerous spotted Californian *Ariolimaces*, and found them invariably to have the extremely characteristic genitalia of *Columbianus*. Proof that a spotted form occurs in the other species is lacking.

**A. Columbianus** var. **stramineus** Hemphill. Pl. XII, fig. 1.

Alcoholic specimens clear, light buff. Length 59; greatest breadth (across shield) 19; greatest width of sole 15 mm. Genitalia as in typical *A. columbianus*.

Habitat: Santa Cruz Island, California.

The specimen figured is one of Hemphill's original lot.

**A. Californicus** Cooper. Pl. XIII, figs. 5, 6; Pl. XIV, figs. 14-16.

*Ariolimax Californicus* J. G. Cooper, Proc. Acad. Nat. Sci. Phila., 1872, p. 146, pl. 3, f. D, 1-3. W. G. Binney, Proc. Acad. Nat. Sci. Phila., 1874, p. 33; Am. Lyc., N. Y., X, 1873, p. 297; Terrest. Moll., V. p. 232, pl. v, fig. F (dentition), and pl. xii, f. D (genitalia); Man. Amer. Land Sh., p. 99 f. 62, 63; Third Suppl. Terr. Moll., V (Bull. M. C. Z., XIX, No. 4), p. 211, pl. v. f. E (living animal) and f. H (penis). Simroth, Nova Acta Acad. Caes. Leop. Carol. Germ. Nat. Cur., LVI, 1891, p. 365, pl. 7 [xv], f. 9-11; Malak. Blätter (n. F.) XI, pl. 1, f. 5. 6.

**DISTRIBUTION:** We have seen this species from San Mateo Co., California, only.

Color of alcoholic specimens brownish ochraceous, sole gray; foot margin uniform with the upper surface, or dusky with vertical dark lines.

The free anterior portion of mantle is shorter than in *A. Columbianus*, less than one-fourth the entire length of the mantle.

Jaw (Pl. XIV, fig. 13) with about 9 ribs, denticulating both margins.

Radula (Pl. XIII, figs. 5, 6) with the formula 67.1.67. Rhachidian teeth with well developed side cutting-points; mesocone long, reaching to posterior edge of basal plate. Inner lateral teeth, without inner cusps, otherwise similar; outer laterals becoming oblique, with long mesocones, the ectocone gradually reduced to a slight sinuation.

The transition to marginals is extremely gradual; the latter being at first as described above (fig. 5, at 24, 25, 46), but about 20 at the outer edge of radula are of the form shown in fig. 6, with distinct ectocones, and the short, Helicid form of basal plates of other *Arionidæ*.

Genitalia (Pl. XIV, fig. 14) somewhat as in *A. Columbianus*. The ♂ and ♀ orifices are, as Binney has remarked, hardly united in an atrium (see figure). The penis is fleshy, with plicate inner walls, and its retractor is short and fleshy, as in *Columbianus*, but is extremely broad. The epiphallus (*epi.*) is very stout, nearly as large in calibre as the penis in sexually mature specimens. Further downward it becomes very small again, approaches the penis, follows it to its apex, turns in (fig. 15, enlarged view of apex of penis) and is introverted and invaginated therein for some distance, nearly as far as the insertion of retractor muscle (fig. 16, distal end of penis opened, showing the invaginated epiphallus).<sup>6</sup>

The female organs are as usual, except that there is a broad, stout, fleshy vaginal retractor muscle inserted near the base of vagina.<sup>7</sup>

It will be seen that this species shows a less advanced stage of penis structure than *A. Columbianus*, although of the same kind. The very stout, low, vaginal retractor is also a diagnostic feature.

#### INSUFFICIENTLY KNOWN ARIOLIMACES.

*Ariolimax Columbiana* var. *Hecoxi* Wetherby (Some Notes on American Land Shells, p. 6) from Santa Cruz, California, is stated by Wetherby to differ from *A. Columbianus* in the genitalia, but no characters whatever of the new form are mentioned. Binney (Manual American Land Sh., p. 103) apparently endorses the specific value of the form; but beyond stating that it has about 60.1.60 teeth (*Columbianus* varying from 56.1.56 to 67.1.67), with about 16 laterals, he gives no characters. The form has been mentioned in various lists, etc., by Cockerell and the senior author of this paper, but in the entire absence of diagnosis it can have no standing, and had better be dropped until described. We have not seen specimens, nor, in fact, any specimens of the genus from Santa Cruz.

*Ariolimax Costaricensis* Cockerell, Annals and Mag. Nat. Hist. (6), VI, 1890, p. 279, described as a sub-species of *A. Californicus*, from

<sup>6</sup> The slender distal end of the penis has been erroneously described as a "flagellum" by Binney, "Blindschlauch" by Simroth; both overlooking the fact that the epiphallus runs up to its apex, as shown in our figure 15.

<sup>7</sup> Binney (Man. Amer. Land Sh., p. 100) calls the structure a "vaginal prostate," overlooking the easily ascertainable fact that it is composed of solid muscular tissue, similar to that of the penis retractor. All Ariolimaces have vaginal retractors, and at times invert and protrude the vagina, like a penis.

alcoholic specimens in Brit. Mus. The only diagnostic words of Cockerell's description are the locality, "Costa Rica." The other characters mentioned in the description are common to *Columbianus* and some *Californicus*. Measurements, etc., as given therein, look well on paper, but every practical limacologist knows them to be merely an empty form. We consider *Costaricensis* as probably a good species, on account of its locality (if correct), but a diagnosis is still wanting.

Genus **APHALLARION** P. & V. (n. g.).

External characters, jaw, radula and digestive tract, shell, and general internal topography, as well as female genitalia, as in *Ariolimax*; penis (and its retractor) completely wanting, a small and short epiphallus lying in its place; right eye retractor passing to the left of the genitalia.

We institute this new group for a large slug like *Arion* and *Prophysaon* in the total lack of a penis and its appendages, and like *Ariolimax* in the other essential features, internal and external, except the disposition of the eye-retractor mentioned above.

In view of the high development and complicated structure of the penis in *Ariolimax*, the strength of its retractor, the large size and extraordinary introverted character of the epiphallus, we can hardly refuse generic rank to a form differing so radically as this one. The anterior position of the genital foramen in *Aphallarion*, the posterior position of its breathing pore, and the anterior ovotestis, pressed against the base of the albumen gland, deny to our slug entrance into *Arion*; and in the genus *Prophysaon* the whole internal topography<sup>8</sup> as well as the type of digestive system is profoundly different.

**A. Buttoni** P. & V. (n. sp.). Pl. XII, figs. 3, 4, 5.

Color of alcoholic specimens light yellow-brown, the shield lighter, more yellowish, especially anteriorly. Foot-margin dusky, with close vertical black lines, alternately heavier, and seen under the lens to be impressed and pigmented wrinkles. Sole gray, more or less dusky. Anterior third of the mantle free. Length 82; length of mantle 34; greatest breadth of sole 21 mm.

Shell oblong, nearly flat, well calcified; white below, with a yellowish cuticle above, except toward the middle. Length  $12\frac{1}{2}$ , width  $6\frac{3}{4}$  mm.

<sup>8</sup> By this we mean the positions of the organs in the body-cavity, both relative and actual. The relative positions of genitalia and digestive tract are greatly varied in different genera of slugs, and of considerable systematic value.

Mr. Button writes of the living animal as follows: "He has a way of occasionally raising up the mantle over the respiratory orifice, as shown in the sketch, which is characteristic. The following are some measurements of a very large specimen: Length, over all, when extended, 7 inches; width,  $\frac{7}{8}$  in.; height,  $\frac{7}{8}$  in.; length of tentacles,  $\frac{3}{4}$  inch. The color is the same throughout, shield included, being an olive brown."

Figures 4 and 5 of Plate XII were drawn from sketches of the living animal furnished by Mr. Button. Fig. 3 represents an alcoholic specimen, dorsal view.

Jaw with 10 to 12 ribs (Pl. XIV, fig. 11). Teeth as in *Ariolimax Californicus*, but the outer laterals and marginals have the cusps shorter, less thorn-like, and there are rather fewer bicuspid outer marginals.

General characters of the digestive system (Pl. XIII, fig. 4) as in *Ariolimax Columbianus*; but the ascending gut from posterior loop passes under the stomach (instead of over it) and the descending gut from anterior to posterior loop makes one spiral turn less than in that species.

Genitalia (Pl. XIV, fig. 12) lying in the body-cavity like that of *Ariolimax*. Penis absent, the epiphallus (*epi.*) small and short. Vagina very long, strong, with plicate internal walls, and provided with a band of retractor fibers. Spermatheca large, of irregular shape, on a short duct.

Oakland, California (Fred L. Button!).

## EXPLANATION OF PLATES.

### PLATE XII.

- Fig. 1. *Ariolimax Columbianus stramineus* Hemph., lateral view of an alcoholic specimen.
- Fig. 2. *Ariolimax Columbianus* Gld., lateral view of an alcoholic specimen of form *maculatus*, from Tacoma, Washington.
- Fig. 3. *Aphallarion Buttoni* Pils. & Van., dorsal view of an alcoholic specimen of average size.
- Fig. 4, 5. *Aphallarion Buttoni* Pils. & Van., lateral view and dorsal outline of a large living individual in motion, drawn from sketches by Fred. L. Button.

All figures natural size.

## PLATE XIII.

- Fig. 1. *Ariolimax Columbianus* Gld. General view of viscera, the upper integument removed, viscera turned aside, and penis lifted from its normal position across salivary glands and crop.
- Fig. 2. *A. Columbianus*. Digestive tract, the salivary glands and liver removed; albumen gland remaining in place.
- Fig. 3. *Arion hortensis* Fér. (specimen from New Bedford, Mass.). Digestive tract, the liver removed; also showing position of the ovotestis.
- Fig. 4. *Aphallarion Buttoni* P. & V. Digestive tract, the salivary glands and liver removed.
- Figs. 5, 6. *Ariolimax Californicus* Cooper. Dentition.

## PLATE XIV.

- Fig. 7. *Ariolimax Columbianus* Gld. Genitalia of an unicolorous specimen.
- Fig. 8. *Ariolimax Columbianus* Gld. Lower portion of the genitalia of a black-spotted specimen.
- Fig. 9. *Ariolimax Columbianus* Gld. Vagina and penis opened, the latter showing invaginated epiphallus (*epi.*), its structure shown by dotted lines.
- Fig. 10. *Ariolimax Columbianus* Gld. Jaw.
- Fig. 11. *Aphallarion Buttoni* P. & V. Jaw.
- Fig. 12. *Aphallarion Buttoni* P. & V. Genitalia, epiphallus shown at *epi.*
- Fig. 13. *Ariolimax Californicus* Cooper. Jaw.
- Fig. 14. *Ariolimax Californicus* Cooper. Genitalia.
- Fig. 15. *Ariolimax Californicus* Cooper. Enlarged end of penis.
- Fig. 16. *Ariolimax Californicus* Cooper. Enlarged distal portion of penis split to show the invaginated epiphallus.